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A Cost Analysis of Clearing a Ponderosa Pine Watershed

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Costs of clearing a ponderosa pine watershed following a commercial logging operation are analyzed. Cost of felling unmerchantable small trees and windrowing slash was $72.09 per acre. Costs could probably be reduced 40 percent or more by changes in treatment prescription, choice of equipment, and removal of pulpwood and firewood where markets are available.

Keywords: Forest conversion, forestry business economics, production function, watershed management, *Pinus ponderosa*.

The development of many communities in the semiarid Southwest may be curtailed by insufficient water for agriculture, industry, and home use. One possibility to alleviate the water shortage problem is to increase streamflow by manipulating vegetation on upstream watersheds (Worley 1965).

The Beaver Creek Project was initiated to pilot test alternative land management treatments, and evaluate the effects on water and sediment yields, timber and forage production, and wildlife use. The costs associated with establishing these treatments are tabulated, analyzed, and compared with costs from other treatments.

The Beaver Creek watershed is divided into small pilot watersheds, 200 to 2,000 acres in size, and a single treatment has been applied or is planned for each of these areas. The specific treatment described in this cost analysis was designed primarily to increase water yield. It involved removal of all the timber overstory and windrowing the resultant slash. Other treatments being evaluated include stripcutting and thinning of various intensities, as well as livestock grazing. One watershed is scheduled for moderate thinning to maximize timber production, and another will be cut in patterns to enhance wildlife habitat. The treatments are designed to determine levels of production and environmental effects associated with a range of cutting intensities.

This report, the third of a series (Miller and Johnsen 1970, Miller 1971), presents costs incurred during a clearing treatment designed to increase water yield. The 455-acre watershed was treated by first removing merchantable ponderosa pine (Pinus ponderosa Laws.) saw logs and poles through a commercial timber sale, then by felling the remaining trees with chain saws, and bulldozing trees and slash into windrows. The stand remaining after the timber sale consisted of about 500 trees per acre, mainly ponderosa pine poles below 10 inches diameter breast height (d.b.h.), and scattered Gambel oak (Quercus gambelii Nutt.) and alligator juniper (Juniperus deppeana Steud.) ranging in size up to about 50 inches d.b.h.

Treatment Procedures

The study was concerned only with costs to the land management agency over and above normal timber sale administration. Because logging operations generally are self-supporting,

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this study was limited to the clearing operations subsequent to logging. For cost collection and analysis, these operations were separated into component jobs (Worley et al. 1965): (1) felling of small unmerchantable trees with chain saws, (2) layout of windrow locations, and (3) windrowing slash by bulldozer. Data were collected on supervision, labor, equipment, and vehicle use.

Felling was done by three sawyer crews of five to six men per crew. Working conditions for felling were generally good. The watershed is relatively flat, with less than a third of the total area having slopes of more than 10 percent. While the soil surface is rocky, this was not ordinarily a limitation in any of the jobs. All trees to a minimum d.b.h. of about 1 inch were felled. The felling job required 12.31 man-hours per acre (table 1) and included 80 percent of total labor inputs.

Windrows were spaced 100 feet apart and oriented generally with the slope. Spacing and orientation were designed exclusively for the experimental purposes of influencing snow accumulation, snowmelt, and runoff, without regard to cost factors (fig. 1). The work of laying out windrows was a relatively minor job, and was carried out by the bulldozer swamper with part-time help of another worker during the pushing operation.

Table 1.--Labor and supervision inputs in man-hours per acre for the felling and windrowing jobs

Inputs	Felling	Windrowing slash (includes layout)	Total
Supervision	3.09	0.37	3.46
Labor	9.22	2.24	11.46
Total	12.31	2.61	14.92

Three different types of bulldozer equipment were used in the windrowing job: (1) a crawler tractor of 140 drawbar horsepower with cable-controlled dozer blade, (2) a crawler tractor of 100 drawbar horsepower with a hydraulically controlled blade with rake teeth, and (3) a four-wheel-drive, articulated-frame, rubber-tired tractor with hydraulic blade. The small crawler tractor was found least costly and most efficient at 1.01 hours per acre.

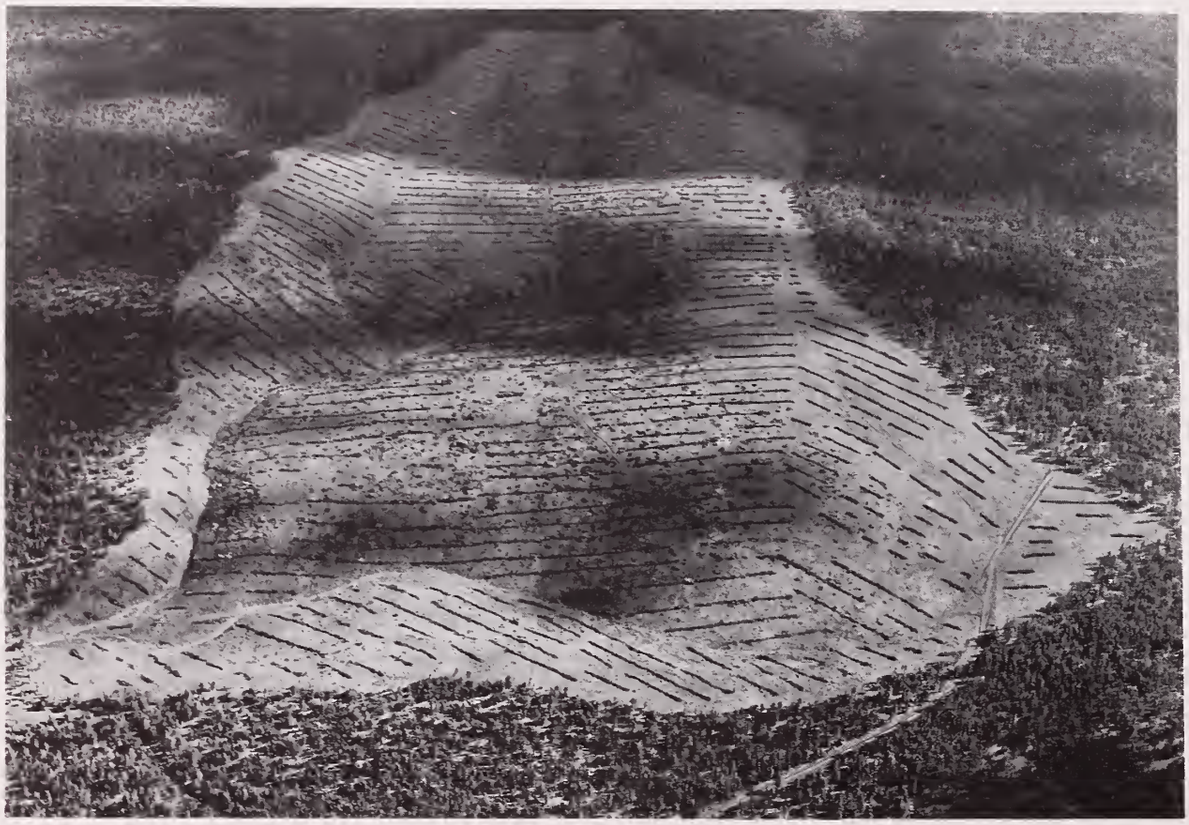

Figure 1.—Aerial view of the 455-acre clearcut watershed. The "herringbone" pattern is the result of slash windrows oriented to enhance snowpack accumulation, snowmelt, and runoff.

Figure 2.—Leaving large Gambel oak and alligator juniper trees would reduce treatment costs without appreciably reducing water yields or forage production, and may improve wildlife and recreational values.

Figure 3.—Experienced thinning crews felled unmerchantable trees.

Treatment Costs

Total costs of clearing operations subsequent to logging were $72.09 per acre (table 2). Felling costs were $32.88, windrowing $28.96, and travel $10.25.

The variation in input per unit output among job work periods can indicate possible opportunity for improving efficiency. The coefficient of variation is a useful measure for this purpose, since it permits direct comparisons in variability between jobs. Coefficients of variation were computed by standard techniques using cost per acre for each work period. For the felling and windrowing jobs, the coefficients were relatively high at 39.6 and 32.8 percent, respectively. In a continuing operation, such large coefficients would strongly suggest the need for detailed study to determine causes of variation, particularly for jobs that account for large parts of the costs of the operations.

Variation can be caused by vegetation differences, working conditions, or by factors related to methods and performance. Analysis of vegetation and other physical variables can lead to greater efficiency by altering prescriptions for particular conditions. Stand density and composition varied considerably on the watershed, and some grouping of stands would have been possible. The particular effects of these variables were not studied, however.

Other results indicate that felling costs could be reduced by a change in prescription to leave large Gambel oaks and alligator junipers uncut. Large alligator junipers are extremely costly to fell, requiring 20 minutes to 2.5 man-hours (Miller and Johnsen 1970). Felling costs for large oaks may be similar. There were approximately 1.5 trees of these species per acre greater than 24 inches d.b.h. Assuming an average of 1 hour to cut each large tree, a savings of 12 percent or $3.95 per acre could be realized by leaving these trees.

Many of these larger trees were overmature, with low vigor and generally sparse crowns. Leaving such trees uncut would not likely reduce water yield or forage production appreciably, and would improve conditions for wildlife (Reynolds et al. 1970, Clary and Larson 1971) and recreation (fig. 2).

It does not appear likely that costs of felling small trees can be substantially reduced, since felling was done by crews who were experienced in, and equipped for, pine thinning operations (fig. 3). Costs could be greatly reduced, however, if markets existed for pulpwood and firewood. These products were largely unmerchantable because of size in this case, since the treated area was 55 miles from the nearest firewood market and pulp collection yard. Approximately 1,000 cords were available and left standing after the logging operation. This material accounted for approximately 60 percent of the remaining slash; utilization of it probably would have reduced the cost of felling small pine trees by that percentage.

If the original felling cost of $32.88 per acre (table 2) is decreased $3.95 per acre by not felling large oak and juniper, and another 60 percent ($17.36) by utilizing pulpwood and firewood, felling costs would drop to $11.57 per acre.

During the windrowing job, advantages were found for each machine. The production rate of the articulated rubber-tired dozer was median, and cost per acre on the basis of the contract price was favorable (table 3). During the 6 days of operation, however, stumps of small trees caused about $250 in tire damage. If this hazard could be eliminated at small cost by more care in felling, this type of equipment could be quite efficient for the purpose.

The automatic transmission of the smaller crawler enabled it to outperform the larger crawler dozer. This feature maintains gear ratio more nearly at optimum, eliminates shifting

Table 2.--Dollar costs per acre, by component jobs, for the entire treatment

	Felling	Windrowing slash	Travel	Total	Percent of total
MANPOWER:					
Supervisory	$ 8.79	$1.21	$2.13	$12.13	17
Labor	20.87	7.36	5.07	33.30	46
Subtotal	29.66	8.57	7.20	45.43	
EQUIPMENT	3.22	20.39	3.05	26.66	37
Total	32.88	28.96	10.25	72.09	100

Table 3.--Production rates and dollar costs for the three equipment units used

Equipment	Acres per hour	Total cost per acre	Percent of area treated
Large tractor with manual shift and cable dozer	0.38	53.33	12
Smaller tractor with automatic transmission and hydraulic dozer	.99	25.45	81
Articulated, four-wheel-drive rubber-tired dozer	.68	27.10	6

gears manually, and greatly reduces time for shifting between forward and reverse. The automatic transmission was a disadvantage, however, whenever a large rock or stump was encountered by the blade during pushing, since the automatic down-shifting often caused track slippage and digging. When the dozer with the manually controlled transmission encountered such an object, the operator would shift to prevent stalling, and there would usually be little track slippage. Thus surface disturbance was substantially greater on areas worked by the smaller tractor. The blade linkage of the smaller tractor also did not provide sufficient lift to avoid fairly frequent contact with stumps while windrowing (fig. 4).

The production rate with the smaller tractor would be somewhat higher under ordinary operational conditions. Because of time factors related to the experimental treatment, it was necessary to work under very wet ground conditions during a 3-week period, which slowed production. In normal operations, work under such conditions would not be advisable because of excessive soil disturbance.

These considerations indicate that a large tractor with automatic transmission and hydraulic high-lift dozer would probably prove most efficient in the windrowing job.

Opportunities for reducing windrowing costs are quantified in table 3. If the small crawler

Figure 4.—Tractor with automatic transmission and a hydraulically controlled blade with rake teeth windrowing slash.

had been used exclusively, for instance, windrowing costs for the total area would have been $25.45 per acre or 12 percent less than the $28.96 reported in table 2. Other possible cost reductions are summarized in table 4.

Assuming the above reductions in operating costs could be achieved, travel costs would also be lowered due to less work and fewer trips to the watershed. By prorating travel costs to the amount of time spent on each job, a savings of 55 percent or $5.59 could also be obtained. It is evident that travel costs, which made up approximately 14 percent of total treatment costs, should be taken into account in evaluating management alternatives. Because of the substantial travel distances involved in most western forest operations, such costs need to be considered in deciding between areas to treat and in locating roads and field headquarters for large operations. In this case, distance between headquarters and the watershed was 21 miles.

Summary and Conclusions

Several vegetative treatments on upstream watersheds are being evaluated in terms of water and sediment yields, timber and forage production, and wildlife use. A series of strip-cuts and thinning intensities are being studied as well as special treatments designed to maximize either water production, timber growth, or wildlife habitat.

This report presents costs incurred while treating a watershed to maximize water production. The watershed was cleared by first removing merchantable saw logs and poles through a normally conducted timber sale, then by felling the remaining trees with chain saws and bulldozing slash into windrows. Cost information was collected and analyzed on the noncommercial operations following the timber sale to determine what costs were incurred by the land management agency over and above a normal logging sale administration, and what cost reduction could be obtained through modification in equipment or treatment.

The cost of felling unmerchantable small trees and windrowing slash was $72.09 per acre. This figure could probably be reduced approximately 42 percent to $41.71 by not cutting large alligator junipers and Gambel oaks which are costly to fell, by selling pulpwood and firewood, and by using a more efficient tractor to pile slash. The availability of pulpwood markets would offer the largest potential for reducing treatment cost, with a possible reduction of 60 percent in the cost of felling small unmerchantable trees.

These data can be compared with similar information from other treatments to determine

Table 4.--Estimated dollar costs and opporutnities for reducing costs in clearing a ponderosa pine watershed following a commercial logging operation

Opportunities for reducing costs	Original	Cost reduction		Final cost/acre
		Dollars/acre	Percent	
PRESCRIPTION CHANGES:				
Leave large alligator juniper and Gambel oak uncut during the felling job	$ 3.95	$ 3.95	100	$ 0
Reduce felling job by selling pulpwood and firewood	28.93	17.36	60	11.57
Use most efficient tractor for all slash windrowing	28.96	3.48	12	25.48
Subtotal	61.84	24.79		37.05
TRAVEL COSTS	10.25	5.59		4.66
Total	72.09	30.38	42.1	41.71

the optimum treatment mix to apply over large watersheds or basins, given ecological, economic, and physiographic constraints.

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